1-VDC VERSION OF

CMS DT VDC SYSTEM

USER MANUAL

CMS DT group

(status 2008/12/03)

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1 Overview

1.1 Location

The interim version of CMS DT Drift velocity monitoring system consisting of a single VDC (VelocityDriftChamber) is located in the gas room at USC55, at the position shown in Fig. 1.1. The chamber and its ancillary electronics are inside a single rack housing, from top to bottom, the VDC and its trigger, a NIM-crate, a VME-crate, a SY127 mainframe and a standalone 80 V power supply PSP1803 at the back of the rack.

1.2 Operation scheme

As a interim version of the final 6-VDC system at the current system only the drift velocity of the gas from a single source can be measured.

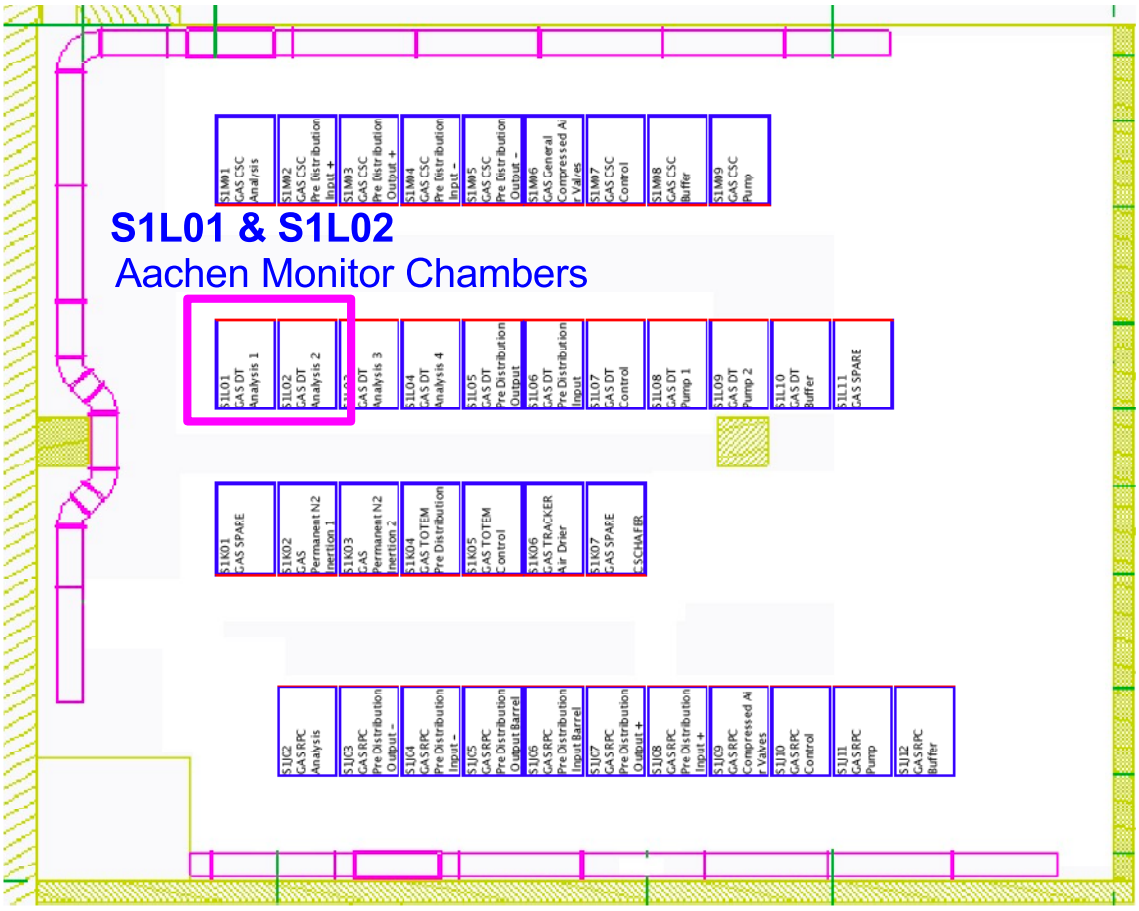

Figure 1.1: *Floor plan of USC55 gas room including the position of the two racks with the VDC system (from* `https://edms.cern.ch/file/684147/3/CMS_Racks_UX.doc` *)*

2 Safety

2.1 General safety rules / safety in the gas room

Note: Keep the CERN safety rules in mind ! **You are not allowed to work alone in a room.** You need a second close to you working person. That means you need a second person which is also in underground as long as you are in underground and you must have contact to his person in intervals of at maximum 30 min. The main risk in the gas room is a lost of oxygen. So leave the door open as long you are in the room. And make sure that the second person will come to the gas room if he or she has no contact with you. (One way to guarantee this is to place some kind alarm clock near to the second person which will give some kind of an "alarm" if it is not disabled before 30 min have elapsed – this job could be done by the "count down" function of a cell phone.)

2.2 Safety related to using the VDC racks

Caution: Radioactive sources (2 ^{90}Sr sources, 10 MBq each) and high voltages are present. Read the VDC ^{90}Sr safety manual (in the rack; also under EDMS, ID 887629) ! Do not plug HV cables or remove any parts of the chamber ! Do not change current limits for the HV supplies ! (Otherwise over currents cannot be detected probably.) Do not set voltages above +2.1 kV for the anode, +2.3 kV for the photo multipliers and +70 V for the silicon photomultipliers (SiPMs). **NOTE: It is forbidden to remove the radioactive source from the chamber or to remove its lead cover !** It is not required to wear a dosimeter during operating the VDC system.

3 Contact Persons

permanently at CERN:	radioactive sources, gas system, storage of spare parts:	Gerd Fetchenhauer (16 3443)
	project supervisor, DCS system, storage of spare parts, Aachen responsible:	**Daniel Teyssier** (16 2680) cell phone: 16 2680 CERN Office: 70488 Aachen: +49 241 80 27316
	other experts:	Alberto Benvenuti (16 3651) Marina Giunta (16 2355)
	CERN gas group:	Roberto Guida (16 2146)
mostly in Aachen:	technical issues, software (**work ended**):	Jens Frangenheim at CERN: 16 4583, 71645 in Aachen: +49 241 80 27265 cell phone: +40 1577 1597265

4 Normal Operation during Running

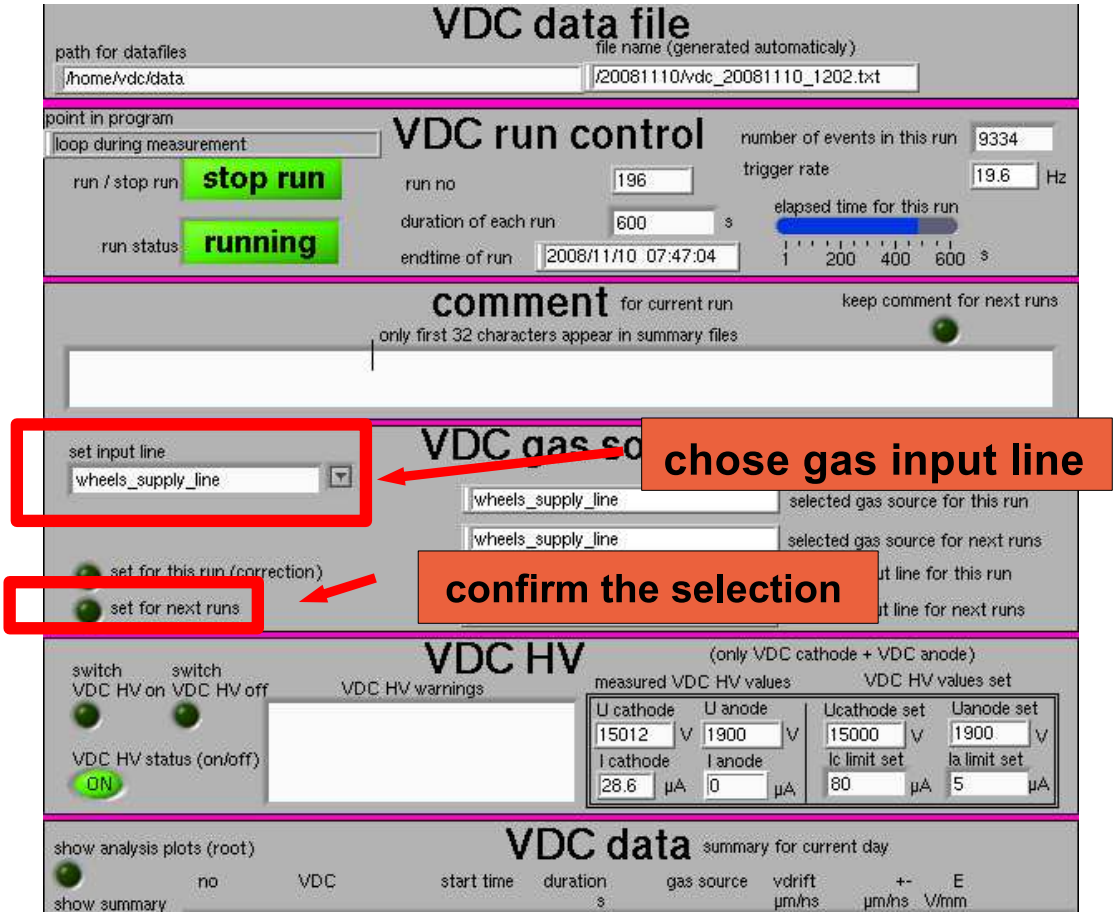

Figure 4.1: *The VDC standard user interface of the VDC readout software.*

In normal continuous run conditions all HVs should be powered on and the software should take data. Also after a power cut everything should be switched on automatically (HV, readout software). Only after a power glitch it might be possible that you have to switch off/on the VME-crate because it crashes.

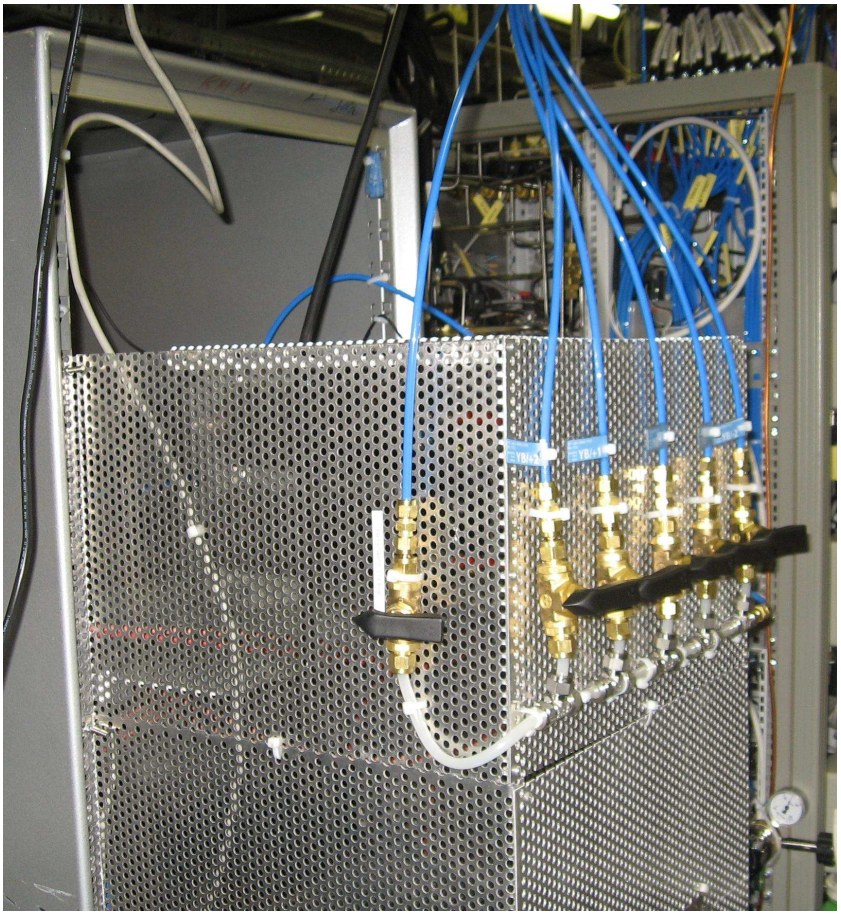

Figure 4.2: *The six valve to selected manually the gas input line of the VDC. Open only one valve at the same time.*

4.1 Setting the gas source

The gas source of the VDC can be chosen from six input lines (see Fig. 4.2) five analysis lines from the gas group analysis rack connected to the outlet of muon chambers (analysis rack YBx) and the gas supply line meaning the common gas supply for all wheels. To change the gas source one has to

- Open the gas valve for the corresponding source at the back of the VDC rack (see Fig. 4.2). All other valves must be closed.
- Set this gas source in the VDC software (see Fig. 4.1) by choosing the gas source from the drop down menu at "set input line" and confirm the selection by clicking on "set for next runs"
- In the case a output line of the gas group analysis rack has been selected the corresponding muon chamber ID is got automatically from DCS.

4.2 Additional things to be checked

The normal operator following things should be done checked:

4.2.1 Online / remote

- Check the v_{drift}-values and the E-field values in the DCS system. (on pccmscr18.cern.ch). They should be at $(55.0 \pm 1.0)\,\mu\text{mns}^{-1}$ resp. $(224.0 \pm 1.0)\,\text{Vmm}^{-1}$.
- If the values are not inside this range (especially if "-1" is displayed for v_{drift} which is indicating an error) login to the VDC-PC "DTGAS-VDC-01–CMS.cern.ch" as user "vdc" from inside the CMS network.
- Change directory to /home/vdc/data/current_date.
- Open the current data file "VCD_analysis_date.txt" or the corresponding root file "VCD_analysis_date.txt.root" and check voltages, currents and rates: $U_{anode} = (1900 \pm 50)\,\text{V}$, $U_{cathode} = (15000 \pm 50)\,\text{V}$, $U(PM1) = (2280 \pm 10)\,\text{V}$, $U(PM2) = (2130 \pm 10)\text{V}$, $U(SiPMs) = (70.60 \pm 0.20)\,\text{V}$, $R(local\ trigger) = (32 \pm 5)\,\text{Hz}$, $R(anode) = (28 \pm 15)\,\text{Hz}$, $R(signal) = (25 \pm 10)\,\text{Hz}$

If the voltage, currents or trigger rate are not in those regions, call an expert. If the anode and signal rate is too low check the gas flow in the DCS. At the moment the remote control / voltage/current readout of the SiPMs is disabled.

4.2.2 In the gas room

- Make sure that the set input line is entered correctly in the readout software.
- Make sure that the gas flow is around 5 L/h by adjusting the flow meter (a rotameter) at the rear side of the VDC rack.
- Make sure that there is a normal gas supply while adjusting the flow, because otherwise if you adjust the gas flow at low supply pressure there will be a huge flow through the VDC when the pressure goes back to its normal value. If there is no gas flow check also if the gas valve at the gas outlet of the VDC is open. If it is not possible to establish a correct gas flow inform Roberto Giuda.
- Check the rates at the counter (module on the right in the NIM-crate, Fig. 5.1), in detail they should be:
  Anode: Between 3 kHz and 6 k Hz, a too low rate indicates a stop of the gas flow, a hight high rates maybe cause by a too high anode voltage. Otherwise there is another error (like an error at the preamplifier inside the VDC). In this case inform an expert.
  PM1 / SiPM1: 90 Hz to 150 Hz, 2 kHz to 8 kHz
  PM2 / SiPM2: 50 Hz to 90 Hz, 2 kHz to 8 kHz
  If the rate is not in this region check the voltage(s) for the (Si)PMs. If the voltage is set correctly and the rate is still not in this region inform an expert shifter.
  (Si)PM1*(Si)PM2 (=trigger rate): 28 Hz to 38 Hz (PM-system), 20 Hz to 50 Hz (SiPM-system)
- Enter one comment, which will be inserted into the data file of the current run (section comment). Optionally the comment can also be included into the files of subsequent runs (until the user changes this setting). Note that the first 32 characters of the comment will also appear in the summary list, which displays one line per run.

5 Switching On/Off

5.1 Switching the System ON

In case the whole system is OFF, one has to:

- Make sure the desired gas to be measured is flowing at 5 L/h through the VDC (rotameter at rear side of VDC rack).
- Switch ON the NIM-crate.
- PM-trigger system: Make sure that the "HV ENABLE" lever at the CAEN N470 module (see Fig. 5.1) is in "ON" position ("HV ON" lights).
- Switch ON the SY127 (at the bottom) mainframe: turn the key to the right.
- Make sure that the "HV ENABLE" lever is in "'ON"' position ("'HV ON"' lights).
- Switch ON the VME crate.
- Switch ON the PC and the monitor, the system logs in automatically.

In case of not using the voltage remote control, you have to power up each channel at the Sy127 and N470 (PM trigger) / PSP1803 (SiPM trigger) manually:

- I case you are not firm in using this old generation of CAEN power supplies: The manual is printed directly on the front plate of the Sy127 device: Select a function by "'F"' followed by the number of the function and confirm by "'#"' and than (for corresponding functions) enter the value you want to set and confirm by "'#"'. Each function has to be chose for the corresponding channel which has to be selected before.
  Example 1: Switching on ch 13: F, 0, #, 13, #, F, 10, #
  Example 2: Setting voltage at channel 13 to 14000 V: F, 0, #, 13, #, F, 1, #, 14000, #
  Example 3: Setting voltage at channel 13 to 12000 V in case channel has already been selected: F, 1, #, 14000, #
  Example 4: View current at channel 13 to 12000 V in case channel has already been selected: F, 7, #
- PM trigger: Check the PM voltage settings (set voltage V0, current limit I0) and the values (voltage, current) at the CAEN N470 module (see Fig. 5.1):
  ch0 (PM1): $U_0 = -2280\,\mathrm{V}$, $I_0 = 2000\,\mu\mathrm{A}$, 1950 µA typ.)
  ch1 (PM2): $U_0 = -2130\,\mathrm{V}$, $I_0 = 2000\,\mu\mathrm{A}$, 1710 µA typ.)
  and switch the channels (ch 0 and ch 1) on.
- SiPM trigger: Check the SiPM voltage settings at the PSP1803 (see Fig. 5.2) at the backside of the rack: U= 70.60 V.
  Use the "menu" button to change between normal and fine voltage set. The current of both SiPMs should be around 4µA, so that is far below the resolution of the PSP1803. Switch the voltage on.

- PM trigger (should not be the case): Check the PM voltage settings (set voltage V0, current limit I0) and the values (voltage, current) at the CAEN N470 module (see Fig. 5.1):
  ch0 (PM1): $U_0 = -2280\,\mathrm{V}$, $I_0 = 2000\,\mu\mathrm{A}$, $1950\,\mu\mathrm{A}$ typ.)
  ch1 (PM2): $U_0 = -2130\,\mathrm{V}$, $I_0 = 2000\,\mu\mathrm{A}$, $1710\,\mu\mathrm{A}$ typ.)
  and switch the channels (ch 0 and ch 1) on.

- Check the VDC cathode voltage setting at the front panel of the SY127 mainframe (see Fig. 5.1) on channel 13. In normal condition it should be set to 15 kV, otherwise the current value is indicated somewhere at the racks. Switch ON the VDC cathode voltage, at the front panel of the SY127 mainframe: select channel 13 and switch it on. ($I_{cathode} = 28\,\mu\mathrm{A}$ to $35\,\mu\mathrm{A}$)

- Check the VDC anode voltage setting at the front panel of the SY127 mainframe on channel 16. It should be set to 1850 V. Switch ON the anode voltage. ($I_{anode} = 0\mu\mathrm{A}$ to $1\,\mu\mathrm{A}$.

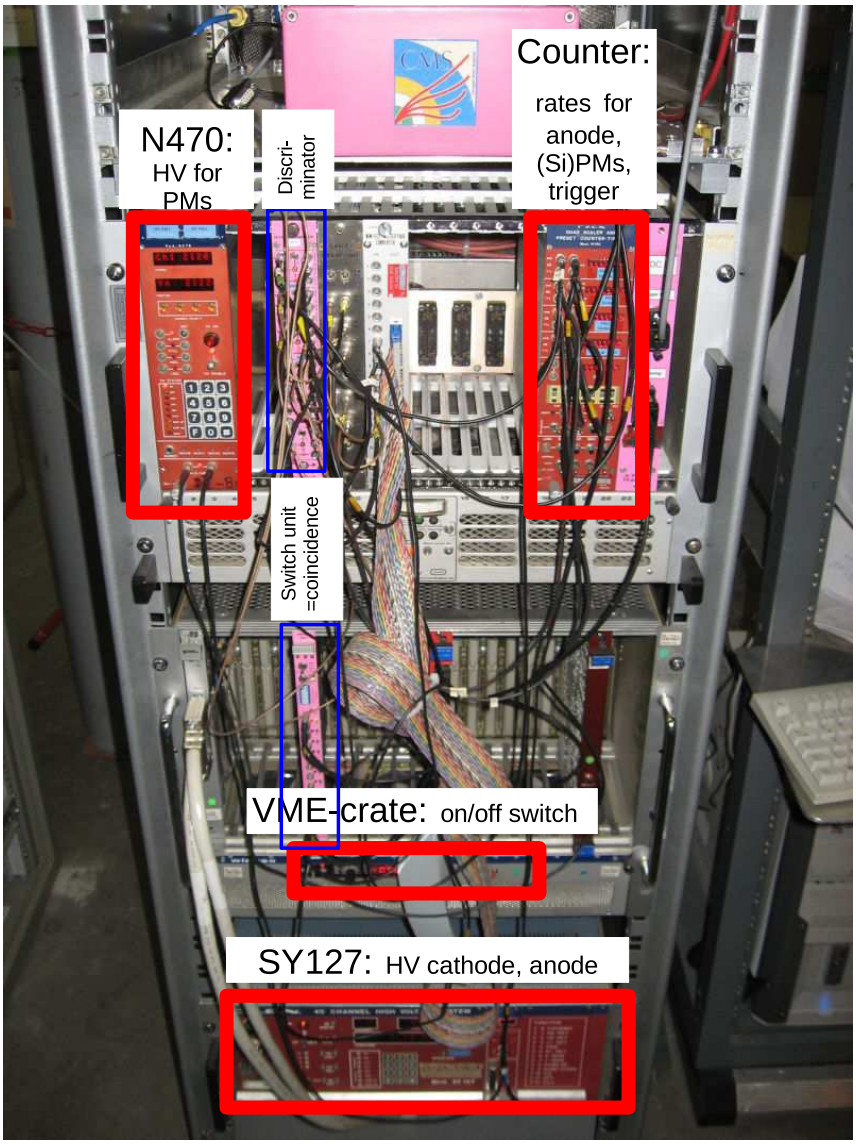

Figure 5.1: *The VDC rack and the modules to be operated.*

5.2 Switching the system OFF

Stop the readout (click on stop button) and/or switch of the high voltage at the software Shut down the PC. Switch OFF the PC, using the switch at its power supply, and the monitor (also at the backside).
In case of not using the voltage remote control, you have to power down each channel at the Sy127 and N470 (PM trigger) / PSP1803 (SiPM trigger) manually:

- **PM trigger:** Power down PM voltages at the CAEN N470 module (at C1), and wait until less than 20 V is measured for both channels, switch "HV ENABLE" down. Never switch of the NIM-crate or switch the "HV ENABLE" lever to disable when the HV for any of the PMs is on ! The PM could be destroyed !
- **SiPM trigger:** Switch off the voltage at PSP1803 at the backside of the rack and than switch off the device.
- **Power down the cathode voltage** at the front panel of the SY127 mainframe (ch 13).
- **Power down the anode voltage** at the front panel of the SY127 mainframe (ch 16).
- **Switch OFF the NIM-crate.**
- **Switch OFF the VME crate.**
- At the SY127 mainframe switch "HV ENABLE" down ("HV ENABLE" lever is in "OFF" position, "HV ON" does not light).
- **Switch OFF the SY127 mainframe:** Turn the key to the left.
- **Stop the gas flow** at the rotameter.

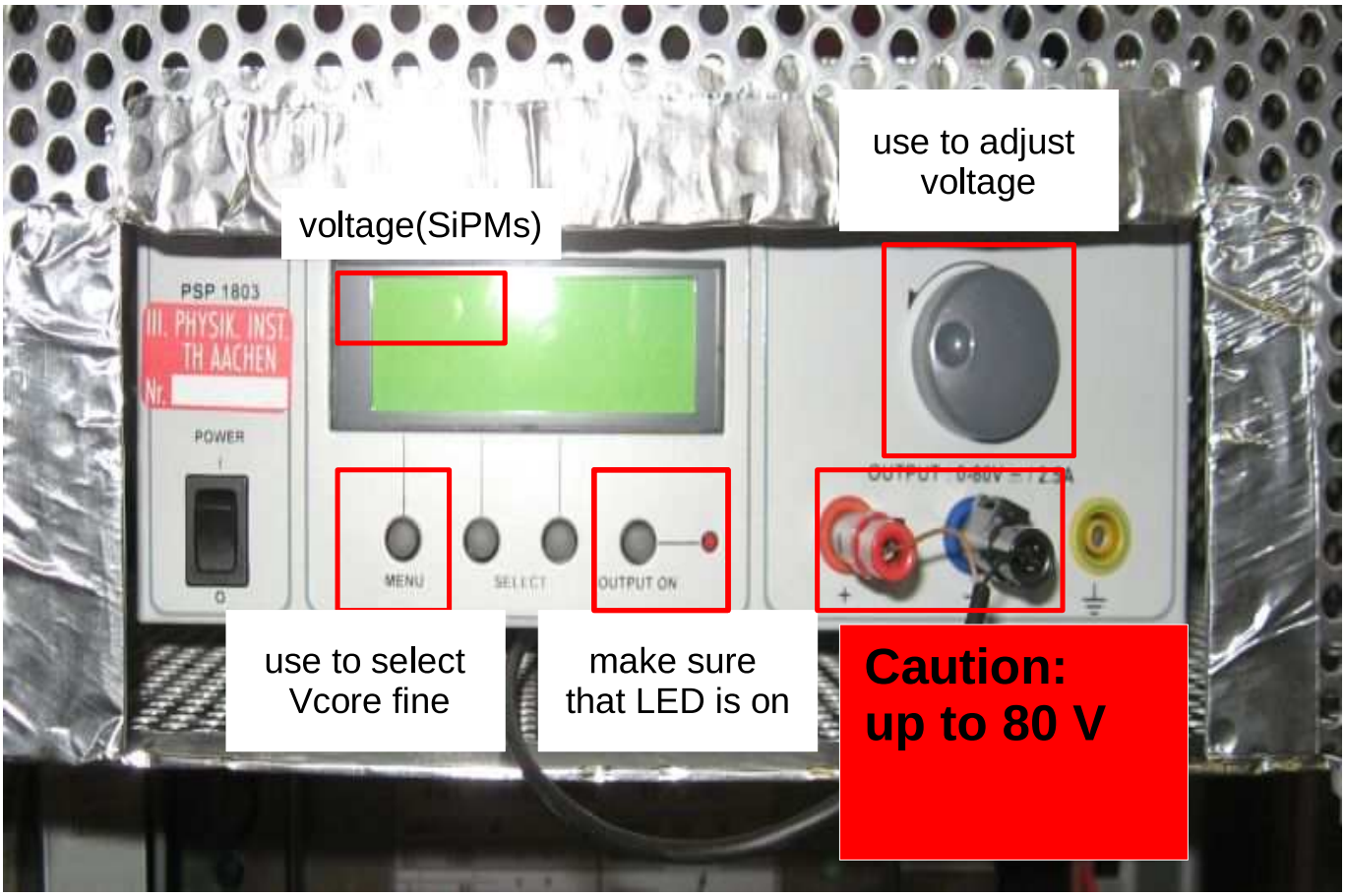

Figure 5.2: *The PSP1803 module used as power supply for SiPM based trigger system.*

6 Expert Settings

6.1 Directories

data:	/home/vdc/data/yyyymmdd (yyyymmdd = date of measurements)
LabView programs (vis):	/home/VDC_software/LabView_software
VDC readout programs:	/home/VDC_software/LabView_software/vdc/VDC_readout
HV steering:	/home/VDC_software/LabView_software/hv
dim-server (DCS system):	/home/vdc/linux
VDC analysis software:	/home/VDC_software/VDC_ver08
output file plotter:	/home/VDC_software/Outputfile_reader
output file merger:	/home/VDC_software/Outputfile_merger
backup	/home/backup

6.2 Data flow

Raw data files: For each run (duration e.g. 10 min) one data file is generated with the name "vdc_yyyyMMmm.txt". For each day a directory named by the date for these raw data files is generated. The raw data format are (UFT-8) text files containing six data types:

- global header
- header
- global block values
- block values
- TDC channel association
- TDC data

Analysis of raw data files: At the end of each run the last written raw data files is analyzed by the C++-program "VDC_ver08". Three files are generated:

1. Histogram file: VDC_rootfile_yyyyMMdd_hhmm.root: Containing histograms including drift time spectra and other evaluations of the TDC data.
2. Analysis file: VDC_analysis_yyyyMMdd_hhmm.txt: Containing all evaluated data from raw data files including the drift velocity. These file has text-format and the content is organized in blocks.
3. Summary file: VDC_summary_yyyyMMdd_hhmm.txt: Containing one block, the Summary block, from the analysis file. The content of this summary block is displayed inside the LabView program. The content of the summary file is read by the dip-server and transmitted to the DCS.

The time (yyyyMMdd_hhmm) inside the filenames is given by the start time of the first measurement of the day (=first file in the directory). The program "VDC_ver08" is reading the filenames of the raw data files inside the current directory and compares them with the names of the files that have already been analyzed using the filenames stored in the summary file. The new data is put into the existing files.
Plots: After each run and the finishing of the "VDC_ver08" program output file plotter program "analysis_reader" is run. It takes the analysis files and plots the values and stored them in the root file "VDC_analysis_yyyyMMdd_hhmm.txt.root". The kinds of the plots can be set by the file "Scrip.dat" inside the directory of the output file plotter.

6.3 Output file merger

To view the data of more than one day inside one plot use the program "Outputfile_merger". It needs two parameters, the start date (yyyyMMdd) and the end date of the period you want to plot. For both dates the corresponding directories must be present. It created a file "VDC_analysis_startdate_to_enddate.txt". Run "outputfile_reader" by "outputfile_reader VDC_analysis_startdate_to_enddate.txt" and you will rechieve a root-file "outputfile_reader VDC_analysis_startdate_to_enddate.txt.root" containing the plots.

6.4 LabView program structure

The outer structure of the LabView program consist of two kinds of while loops: One kind is use to run measurements and the other one to detect user interactions fast. The most important loop is the loop for the data taking: During stopped measurement the problem shall stay in this look and should not enter the inside "if-case".

6.5 Sub-Vis

In/home/VDC_software/Labview_software/vdc:
VDC_readout/HV: setting/ controlling / reading the voltages and current of all devices using the vis in /home/VDC_software/Labview_software/hv

VDC_readout/TDC:

- **TDC_set_parameters.vi:** initialization of the TDC, setting the opcodes and control their setting
- **TDC_readout.vi:** reads the TDC data from the TDC buffer
- **TDC_data.vi:** sorting the TDC_data achieved from TDC_readout.vi

VDC_readout/scripting: vis and data files reading containing the VDC_software parameters
VDC_readout/data_write: vis write the several data block to the output files

6.6 Changing the trigger system

(Please call Gerd Fetchenhauer (16 3443) or Daniel Teyssier (16 2680) to assist you.) If you want to change from one trigger system (PM or SiPM based) to the other one:

- Switch off the voltage to the trigger system you want to remove
- Remove the current trigger system mechanical form the VDC. For the PM-system you have to remove three of the four screws. The remaining screw must be in one the screws in the back. which are fixing the holder to the plate in the rack. Than you can turn the PM system. For the SiPM system remove the four screws which are fixing the trigger unit via its scintillator plate to the VDC and remove the trigger unit from the VDC.
- Place the new trigger unit to the chamber.
- Change the cabling. In principle all cables and connectors should be marked so that you should see what to do. Although in detail:
- Change the cable input to the switch unit: Connect the output of the two discriminator channels which are connected to the output of the trigger system you want to use to the inputs of the switch unit.
- Switch on the voltage (for the PM system power on the N470 channels by hand, for the SiPM system switch on the PSP1808, the rest is done by remote control)
- Select the trigger system in the VDC software. Select "file ", "vi-properties", "protection" and chose unlock. Now Select the new trigger type ("2 scintillator, 2 PMS" or "2 SiPMs Hamamatsu") in the right of the expert setting. Type in also the voltages for the SiPM-s/PMs at "individual voltage settings / set U(SiPMx) (Note: In the software everything is labeled with "SiPM"): PM1=2280 V, PM2= 2130 V, SiPM1=SiPM2=70.60 V. After that mark the corresponding fields and chose "edit", "make selected value default". After that lock the vi again and save the vi. Check if the rate are OK.

7 Locate Hardware Errors

7.1 Detecting errors in the readout system

Follow the flow of the signal starting (target made diagram will be insert).

- At the discriminator: If at any of the three input channels (anode, SiPM1+2) no red LED Is blinking switch the cable from the device to the input of another discriminator channel. If the LED of this channel now is blinking the discriminator channel is out of order and you should do a recabling to the the working discriminator channel. In no LEDs of the discriminator are on the module as a whole is out of order. You can try to recover it by pressing to its upper left side. If it does not help the module needs to be replaces.
- If no data arrive at the discriminator check the LV supply for the devices (VDC LV, trigger unit) with a multimeter. Try to use another output channel for the corresponding SiPM (upper part- called trigger box - of the trigger unit / bottom of the VDC – difficult to reach because the HV-box is in front of it.
- If signal are indicated arriving at the discriminator check if the SiPM signals from the discriminator also arrive at the coincidence (also red LEDs) and if only the corresponding channels (the first two ones, unfortunately wrong labelled as ch7 and ch6) at the switch unit are on (indicated by a green LED).
- For the anode signals you can also test the NIM-to-ECL-converter by switching the another channel (from 9 to 16).

7.2 Detecting HV errors (only for experts)

Please do this only with two people ! Do not work on the VDC when HV is on ! Keep attention when testing parts separately !
To distinguished between problems at the HV-box, the HV-divider and the cathode. Each of these parts can be tested separately by unplugging the corresponding connector from the HV-box.

- **Testing HV-box:** Unplug the connector to the cathode and the HV-divider from the HV-box and ramp up the cathode voltage slowly up to $-15\,\mathrm{kV}$. Even at $-15\,\mathrm{kV}$ the current should be 0 (during ramp ramp the current can be up to $1\,\mu\mathrm{A}$ due to the capacitor inside the HV-box). If the power supply trips replace the HV box (and if necessary also the corresponding cable) by spare parts from the corresponding barrack upstairs.
- **HV divider:** Connect only the HV-divider to the HV-Box and ramp it up the cathode voltage to max. $-5\,\mathrm{kV}$. Because if the cathode is not powered the voltage difference between the cathode and the first layer of field shaping tubes is to large the voltage divider cannot be tested at higher voltages in this configuration. The current at $-5\,\mathrm{kV}$

should be less than 9 µA.
To test the voltage divider at higher voltages, remove it from the chamber and test it on a non conductible surface. If the voltage divider seems to be damaged or you do not want to test it replace it by a spare voltage divider from the barrack upstairs. Keep attention to the cable at the frontside of the HV-divider (to ground): It is fragile.

- **VDC backplate:** Connect only the VDC-backplate (cathode) to the HV-Box and ramp it up the cathode voltage to max. −5 kV (same reason than for the voltage divider). The current at −5 kV should be 0 µA.
  If the backplate has to be removed from the VDC (for replacing or further testing) call the radioactive protection (Gerald Dumont 16-4758) because if the backplate is removed the shielding of the radioactive sources is limited.
  During replacing the backplate (by a spare VDC backplate from the corresponding barrack upstairs) make sure that the backplate and the backside of the VDC is clean and that only the O-ring seal is with high vacuum grease (stored together with the spare parts). Tighten the screw slowly and crosswise.

7.3 Improving the anode rate (only for experts)

If the signal rate decrease slowly (probably an effect of outgasing of the used glue inside the chamber) one can:

1. Set a higher anode voltage (but not more than 2.1 kV and the current should be still 0 µA).
2. Decrease the threshold for the anode at the discriminator (normally −90 mV). Monitor the rate of anode rate and signal rate afterwards.
3. Clean the anode wire: **If the frontplate has to be removed from the VDC call the radioactive protection** (Gerald Dumont 16-4758) because if the frontplate is removed the shielding of the radioactive sources is limited.
   Be very careful ! The anode wire has a diameter of only 25 µm **!**. If the anode wire breaks the whole VDC will have to be replaced (takes up to one week until a new VDC will be sent to CERN). So do this only if there is a shutdown and the VDC cannot be used at the moment or if the anode behaviour is really very bad and the first and second action have failed.
   To clean the anode wire: Remove the front plate and clean the anode wire very carefully using a pincette, a piece of absorbent cotton and alcohol. Do the reinstallment of the front plate like for changing the backplate.

8 Locate Software Errors